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4-12-03

VERIFICATION OF A TRANSLATION

Assistant Commissioner for Patents  
Washington, D.C. 20231  
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I, the below named translator, hereby declare that:

1. My name and post office address are as stated below.
2. That I am knowledgeable in the English language and in the language of JPH11-085844, and I believe the attached English translation to be a true and complete translation of JPH11-085844.
3. The document for which the attached English translation is being submitted is a patent application on an invention entitled X-RAY CAMERA.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so

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Date: 24 March, 2003

Katsuyuki Hirano

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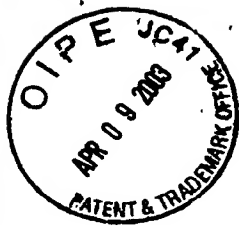
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[DATE OF FILING] March 29, 1999  
[ADDRESS] Director-General of the Patent Office  
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[TITLE OF THE INVENTION] X-ray Photographing Apparatus  
[NUMBER OF CLAIMS] 11

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[REPRESENTATION OF FEE]

[PAYING METHOD] In-advance payment

[NUMBER IN LEDGER OF IN-ADVANCE PAYMENT] 011305

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[LIST OF ARTICLES FILED]

[NAME OF ARTICLE] Specification 1

[NAME OF ARTICLE] Drawing 1

[NAME OF ARTICLE] Abstract 1

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[Title of the Invention] X-ray photographing apparatus

[What is Claimed is]

[Claim 1] An X-ray photographing apparatus, comprising a correction means for correcting the brightness of an image attained by X-ray photography of an intended object with use of a correction factor obtained from brightness data that represents the light and shade of the image attained by X-ray photography of a reference object.

[Claim 2] The X-ray photographing apparatus of claim 1, wherein a preset reference value of brightness is divided by the brightness value of each pixel of the image attained by X-ray photography of a reference object, and the value thus obtained is used as the correction factor of each pixel.

[Claim 3] The X-ray photographing apparatus of claim 1, wherein the mean value of brightness of the image attained by X-ray photography of a reference object is divided by the brightness value of each pixel, and the value thus obtained is used as the correction factor of each pixel.

[Claim 4] The X-ray photographing apparatus of claim 1, wherein the representative value of brightness of an image attained by X-ray photography of a reference object is divided by the brightness value of each pixel, and the value thus obtained is used as the correction factor of each pixel.

[Claim 5] The X-ray photographing apparatus of claim 1, wherein

the correction means multiplies the brightness value of each pixel of the image attained by X-ray photography of an intended object by the correction factor obtained by X-ray photography of a reference object in order to correct the rightness of each pixel.

[Claim 6] The X-ray photographing apparatus of any one of claims 1 to 5, wherein a soft tissue equivalent material, like muscle and fat, made of urethane resin or the like is used as a reference object for obtaining the correction factor.

[Claim 7] The X-ray photographing apparatus of any one of claims 1 to 5, wherein a bone tissue equivalent material made of epoxy resin, aluminum or the like is used as a reference object for obtaining the correction factor.

[Claim 8] The X-ray photographing apparatus of any one of claims 1 to 7, comprising a storage means for storing the correction factor of each pixel attained by X-ray photography of a reference object, and a correction factor setting means for setting the correction factor besides normal X-ray photography in order to obtain the correction factor, wherein resetting of the correction factor can be made timely when the apparatus is initially installed or the user judges it to be needed.

[Claim 9] An X-ray photographing apparatus, comprising a storage means for storing the correction factor of each picture element attained by X-ray photography of an reference object,

a correction factor setting means for setting the correction factor besides normal X-ray photography in order to obtain the correction factor, and a correction means for correcting the brightness of an image attained by X-ray photography of an intended object by using the correction factor, wherein three kinds of values such as the mean value and the representative value of brightness of an image attained by X-ray photography of a reference object and the preset reference value of brightness are divided by the brightness value of each pixel, and the three kinds of correction factors thus obtained are stored in the storage means, and when correcting the brightness of the image attained by X-ray photography of the intended object, one of the correction factors is selected or automatically selected out of the three kinds of correction factors by the correction factor setting means.

[Claim 10] An X-ray photographing apparatus, comprising a storage means for storing the correction factor of each picture element attained by X-ray photography of a reference object, a correction factor setting means for setting the correction factor besides normal X-ray photography in order to obtain the correction factor, and a correction means for correcting the brightness of an image attained by X-ray photography of an intended object by using the correction factor, wherein two kinds of equivalent materials such as soft tissue equivalent material and bone tissue equivalent material are photographed,

and two kinds of correction factors corresponding to the respective equivalent materials are stored in the storage means, and when correcting the brightness of the image attained by X-ray photography of the intended object, one of the correction factors is selected or automatically selected out of the two kinds of correction factors by the correction factor setting means.

[Claim 11] The X-ray photographing apparatus of any one of claims 1 to 10, wherein a plurality of X-ray photographic sensors are arranged in such manner that photographic images overlap each other, and thereby, X-ray images can be photographed in a wider range without error in brightness of overlapped portions.

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

The present invention relates to an X-ray photographing apparatus used in the fields of medicine, dental surgery, etc.

[0002]

[Prior Art]

Conventionally, as an X-ray photographing apparatus of this type, a general X-ray photographing apparatus for photographing the joints of hands and legs or chests which are used in the field of medicine, and an intraoral X-ray photographing apparatus and panorama X-ray photographing apparatus which are



used in the field of dental surgery are well known, and as the image displaying method, a method of printing an X-ray image on a film to obtain a monochromic photo is generally employed.

[0003]

However, in recent years, various types of X-ray photographing apparatuses using digital technology have been developed, and there are proposals that include CR (Computed Radiography) technology wherein an X-ray image is transferred onto a special fluorescent film and then the fluorescent image is read and stored as a digital image by using a laser, technology for directly reading it as a digital image as in video photography by the combination of charge coupled device (hereinafter referred to as CCD) and fluorescent material, and technology for combining TFT (Thin Film Transistor) panel and photo diode used in a liquid crystal display unit in place of CCD.

[0004]

[Problems to be Solved by the Invention]

In the case of an X-ray photographing apparatus using such digital technology, unlike the case of using a film, the method of representation is such that the X-ray photographic image is accurately read pixel by pixel, and the data of individual pixels thus obtained are rearranged on the display to process it into a sheet of image.

[0005]

Accordingly, defective pixels of CCD or TFT and variations in manufacture of the reading circuit for each pixel are reflected intact in the pixel data, which is a defect peculiar to digital X-ray photography, resulting in quality deterioration of the displayed image as delicate change of the brightness.

[0006]

The present invention is intended to solve such conventional problems by improving the quality of X-ray photographic images.

[0007]

[Means to Solve the Problems]

In order to solve the above problem, as the first means, the present invention comprises a correction means for correcting the brightness of an image attained by X-ray photography of an intended object by using the correction factor obtained from the data of brightness that represents the light and shade of the image attained by X-ray photography of a reference object.

[0008]

And as the second means, the preset reference value of brightness is divided by the brightness value of each pixel of the image attained by X-ray photography of a reference object, and the value thus obtained is used as the correction factor of each pixel.

[0009]

And as the third means, the mean value of brightness of the image attained by X-ray photography of a reference object is divided by the brightness value of each pixel, and the value thus obtained is used as the correction factor of each pixel.

[0010]

And as the fourth means, the representative value of brightness of the image attained by X-ray photography of a reference object is divided by the brightness value of each pixel, and the value thus obtained is used as the correction factor of each pixel.

[0011]

And as the fifth means, in the correction means, the brightness value of each pixel of the image attained by X-ray photography of an intended object is multiplied by the correction factor obtained by X-ray photography of a reference object in order to correct the brightness of each pixel.

[0012]

And as the sixth means, a soft tissue equivalent material, like muscle and fat, made of urethane resin or the like is used as a reference object for obtaining the correction factor.

[0013]

Also, as the seventh means, a bone tissue equivalent material made of epoxy resin, aluminum or the like is used as a reference object for obtaining the correction factor.

[0014]

Further, as the eighth means, the invention comprises a storage means for storing the correction factor of each pixel attained by X-ray photography of a reference object, and a correction factor setting means for setting the correction factor besides normal X-ray photography in order to obtain the correction factor, wherein resetting of the correction factor can be made timely when the apparatus is initially installed or the user judges it to be needed.

[0015]

And as the ninth means, three kinds of values such as the mean value and the representative value of brightness of the image attained by X-ray photography of a reference object and the preset reference value of brightness are divided by the brightness value of each pixel, and the three kinds of correction factors thus obtained are stored in the storage means, and when correcting the brightness of the image attained by X-ray photography of an intended object, one of the correction factors is selected or automatically selected out of the three kinds of correction factors.

[0016]

Also, as the tenth means, in X-ray photography of a reference object, two kinds of equivalent materials such as soft tissue equivalent material and bone tissue equivalent material are photographed, and two kinds of correction factors corresponding

to the respective equivalent materials are stored in the storage means, and when correcting the brightness of the image attained by X-ray photography of an intended object, one of the correction factors is selected or automatically selected out of the two kinds of correction factors.

[0017]

And as the eleventh means, a plurality of X-ray photographic sensors are arranged in such manner that photographic images overlap each other, and thereby, X-ray images can be photographed in a wider range without error in brightness of overlapped portions.

[0018]

[Description of the Preferred Embodiments]

Because of the first means, it becomes possible to prevent quality deterioration of the X-ray photographic image which is caused due to variations peculiar to the X-ray photographic sensor.

[0019]

Because of the second means, it becomes possible to perform the calculation of correction factors used for correcting the brightness of X-ray image at a high speed.

[0020]

Also, because of the third means, it becomes possible to obtain the correction factor in accordance with the actual characteristics of the X-ray photographic sensor used, thereby

enhancing the accuracy of correction.

[0021]

Further, because of the fourth means, when setting the correction factor used for correcting the brightness of an X-ray image, it is not necessary to calculate the mean value of brightness while maintaining the accuracy of correction required and becomes possible to make the setting at a relatively high speed.

[0022]

Also, because of the fifth means, it becomes possible to efficiently correct the brightness of an image by using the correction factor obtained by X-ray photography of a reference object.

[0023]

And because of the sixth means, it becomes possible to improve the quality of the X-ray photographic image of a soft tissue portion like chest and internal organs.

[0024]

Also, because of the seventh means, it becomes possible to improve the quality of the X-ray photographic image of a bone tissue portion like hand, leg, and joint.

[0025]

Further, because of the eighth means, it becomes possible to reset the correction factor timely when the user judges it to be needed.

[0026]

And because of the ninth means, it becomes possible to select from a plurality of correction factors according to the user's choice.

[0027]

Also, because of the tenth means, it becomes possible to select the optimum correction factor in accordance with the portion to be X-ray photographed.

[0028]

And because of the eleventh means, it becomes possible to compensate for the local reduction of brightness of the sensor overlapping portion in the X-ray photographing apparatus using a plurality of X-ray photographic sensors.

[0029]

(Preferred Embodiment 1)

The preferred embodiment 1 of the present invention will be described in the following with reference to Fig. 1 to Fig. 5.

[0030]

Fig. 1 shows a state of one embodiment of the image brightness correcting operation when a staircase-like model being an intended object is X-ray photographed on the basis of the correction factor obtained by X-ray photography of a reference object.

[0031]

In the figure, reference numeral 1 is a reference object, and numeral 2 is an X-ray photographic sensor mounted on board 7, having a scintillator (not shown) on the surface thereof. Generally, CCD and TFT are employed. Reference numeral 3 is a staircase-like model made of aluminum or the like, which is an intended object used in place of human body.

[0032]

Here, the image brightness correcting operation is explained.

[0033]

In Fig. 1, when X-ray is applied to the reference object 1 shown at left, the X-ray penetrates the object 1 and is converted into optical signal by the scintillator (not shown) and detected as an image by the X-ray photographic sensor 2.

[0034]

And, an example of brightness distribution of an array of pixels in the one-dimensional direction of the image thus attained is the graph shown under the X-ray photographic sensor 2, and the brightness that should be originally constant in value is delicately fluctuated every pixel due to the inherent variations of the X-ray photographic sensor 2 or detection circuit (not shown).

[0035]

Therefore, as shown in Fig. 1, the brightness value that is the design value of X-ray photographic sensor 2 and should



be originally outputted is used as the preset reference value of brightness  $L_a$ , and the value  $L_a$  is divided by brightness value  $L_n$  of an image  $n$ , and the value  $L_a/L_n$  thus obtained can be set every pixel as the correction factor of the image  $n$ .

[0036]

Next, staircase-like model 3 that is an intended object as shown at the right-hand side of Fig. 1 is X-ray photographed by using the same X-ray photographic sensor 2, the image output displays the distribution of brightness as shown at middle right because the inherent variations is reflected therein.

[0037]

In that case, in case the brightness value of a pixel  $n$  is  $L_n'$ , the  $L_n'$  is a brightness value including the inherent variations as against the original brightness of the image.

[0038]

Therefore, by multiplying  $L_n'$  by the correction factor  $L_a/L_n$ , the original brightness value of the image ( $L_n' \times L_a/L_n$ ) can be obtained, and thereby, it is possible to obtain the distribution of brightness as shown at bottom right.

[0039]

Here, in the above description, a preset reference value of brightness (design value)  $L_a$  is used for obtaining the correction factor, but it is also preferable to use the mean value of brightness of all images, and further, to use the representative value of brightness of all images (for example,

maximum value, medium value or minimum value). By using the mean value or the representative value instead of the design value  $L_a$  to make the correction in accordance with the variations of individual X-ray photographic sensors, the correction factor can be set in accordance with the brightness characteristics displayed by the X-ray photographic sensor 2 actually used, and therefore, it is possible to further enhance the accuracy. Also, which of the mean value and the representative value is used depends upon the features of each computation. That is, when high accuracy is required, the mean value is used, and when high-speed processing is required, the representative value is used.

[0040]

Also, the accuracy can be enhanced by using the value obtained through division such as  $L_a/L_n$  as the correction factor set for each pixel rather than by using the value obtained through subtraction such as  $L_a - L_n$  that is influenced by the intensity of external light or illumination.

[0041]

As a reference object, it is also preferable to use a soft tissue equivalent material, like muscle and fat, made of urethane resin or a bone tissue equivalent material made of epoxy resin, aluminum or the like.

[0042]

The operational flow charts of the whole X-ray

photographing apparatus in one preferred embodiment of the present invention are shown in Fig. 2 and Fig. 3.

[0043]

In Fig. 2, when correction factor setting operation is selected at start of the X-ray photographing apparatus, the system goes to the mode of X-ray photography of a reference object (the flow at right in the figure), and thereby, the correction factor is calculated at the correction factor setting means 4 in accordance with the brightness data of the image attained. And, the correction factor obtained for each pixel is stored in the storage means 5 provided with a semiconductor memory and hard disk or the like, and then the system goes back to the mode at start.

[0044]

And, in this condition, when each part of human body being an intended object is X-ray photographed (the flow at left in the figure), a correcting calculation using the correction factor stored in the storage means 5 is additionally made at the correction means 6 in the figure with respect to each pixel of the image attained by the X-ray photography, and then the correct X-ray image without variations inherent to the apparatus is displayed on the display unit.

[0045]

Fig. 3 is an example of configuration in that a plurality of correction factors are stored, wherein one of the correction

factors can be selected out of the correction factors stored in the storage means.

[0046]

When setting a plurality of correction factors, by setting or storing correction factors obtained from a reference object changed in thickness by several kinds, it is also possible to select the optimum correction factor in accordance with the thickness of the portion of the human body to be photographed.

[0047]

Also, Fig. 4 and Fig. 5 show the preferred embodiment using a configuration in that a plurality of sensors are arranged in an overlap fashion as X-ray photographic sensors: an example of similarly overlapped arrangement of a plurality of sensors as in Fig. 4, and that of stepped hill-like arrangement (Fig. 5).

[0048]

In the above arrangement, the effective photography zones (usually narrower than the outside dimension of the X-ray photographic sensor) of the X-ray photographic sensors are overlapped in order to detect the image without missing any portion, and it is set so that the sensor image in front of the object is adopted as the image of the overlapped portion. In that case, as shown in Fig. 4 and Fig. 5, in the effective photography zone of the sensor arranged at the back, the portion within the outside dimension of the sensor appears as a shade

outside the effective photography zone of the front sensor, and only the portion is locally reduced in brightness, and this phenomenon is the most serious problem.

[0049]

In the X-ray photographing apparatus of the present preferred embodiment, since the correction factor is obtained for each pixel  $n$ , and the correction is made very pixel, it is effective even when a plurality of sensors are arranged in an overlap fashion as X-ray photographic sensors as described above, and as shown in Fig. 4 and Fig. 5, it is possible to execute sufficient correction of brightness.

[0050]

[Advantages of the Invention]

As described above, according to the present invention, since the X-ray photographing apparatus is provided with a function of correcting the brightness of the image attained by photography, it is possible to greatly improve the quality of the X-ray image, eliminating brightness errors due to inherent variations of sensors, image detecting circuits or the like peculiar to an X-ray photographing apparatus.

[0051]

Also, since a plurality of correction factor calculating methods and of reference objects used for correction factor setting can be selected according to the purpose of photography, it is possible to make delicate correction of image quality in

accordance with the object and portion to be photographed.

[0052]

It is very useful for X-ray image diagnosis in the field of medicine.

[0053]

Further, since it can cope with brightness correction of sensor overlap portions in a type of apparatus using the combination of a plurality of sensors to achieve a wide photographic area, it is very useful for X-ray image diagnosis in the field of medicine.

[Brief Description of the Drawings]

Fig. 1 is a block diagram showing the principle of operation of an X-ray photographing apparatus in the preferred embodiment 1 of the present invention.

Fig. 2 is a flow chart showing the operational flow of the X-ray photographing apparatus.

Fig. 3 is a flow chart showing the operational flow of an X-ray photographing apparatus in another preferred embodiment of the present invention.

Fig. 4 is a block diagram showing the operation in sensor shape of an X-ray photographing apparatus in another preferred embodiment of the present invention.

Fig. 5 is a block diagram showing the operation in sensor shape of an X-ray photographing apparatus in another preferred

embodiment of the present invention.

[Description of the Reference Numerals]

- 1 Reference object
- 2 X-ray photographic sensor
- 3 Stepped hill-like model (intended object)
- 4 Correction factor setting means
- 5 Storage means
- 6 Correction means

[Name of the Document] Abstract

[Abstract]

[Object] Defective pixels of CCD, TFT or the like and variations in manufacture of circuits for reading pixel by pixel are reflected intact in the pixel data, causing the quality of the displayed image to be deteriorated as delicate change in brightness, that is a defect peculiar to a digital X-ray photography.

[Means to Solve the Problem] There is provided a correction means for correcting the brightness of the image attained by X-ray photography of an intended object by using the correction factor obtained from the brightness data that represents the light and shade of the image attained by X-ray photography of a reference object.

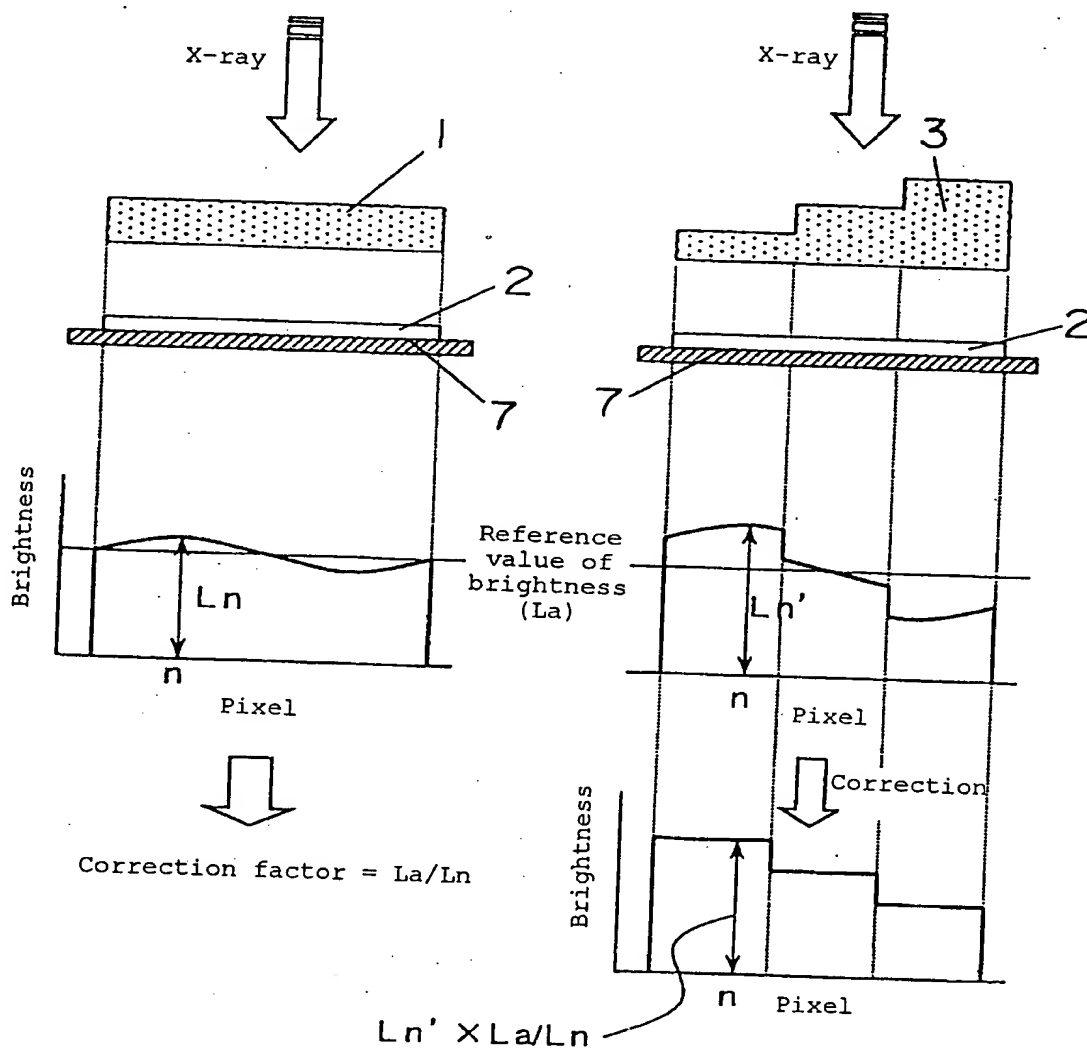
[Selected Drawing] Fig. 1



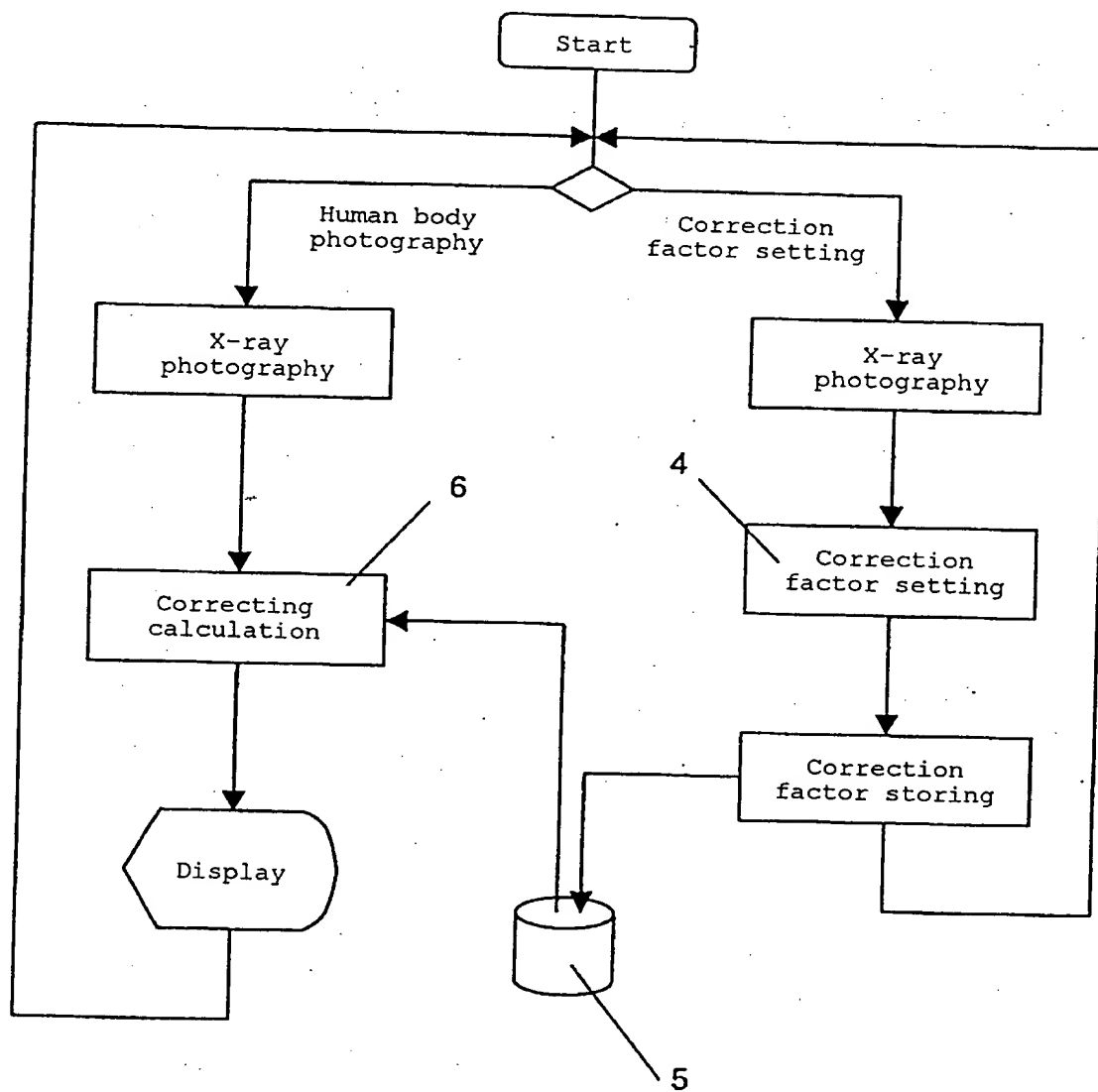
[Name of the Document] Drawing

[Fig. 1]

- 1 Reference object
- 2 X-ray photographic sensor
- 3 Stepped hill-like model (intended object)
- $L_a$  Preset reference value of brightness (design value)
- $n$  Pixel
- $L_n, L_n'$  Brightness value of pixel  $n$
- $L_a/L_n$  Correction factor

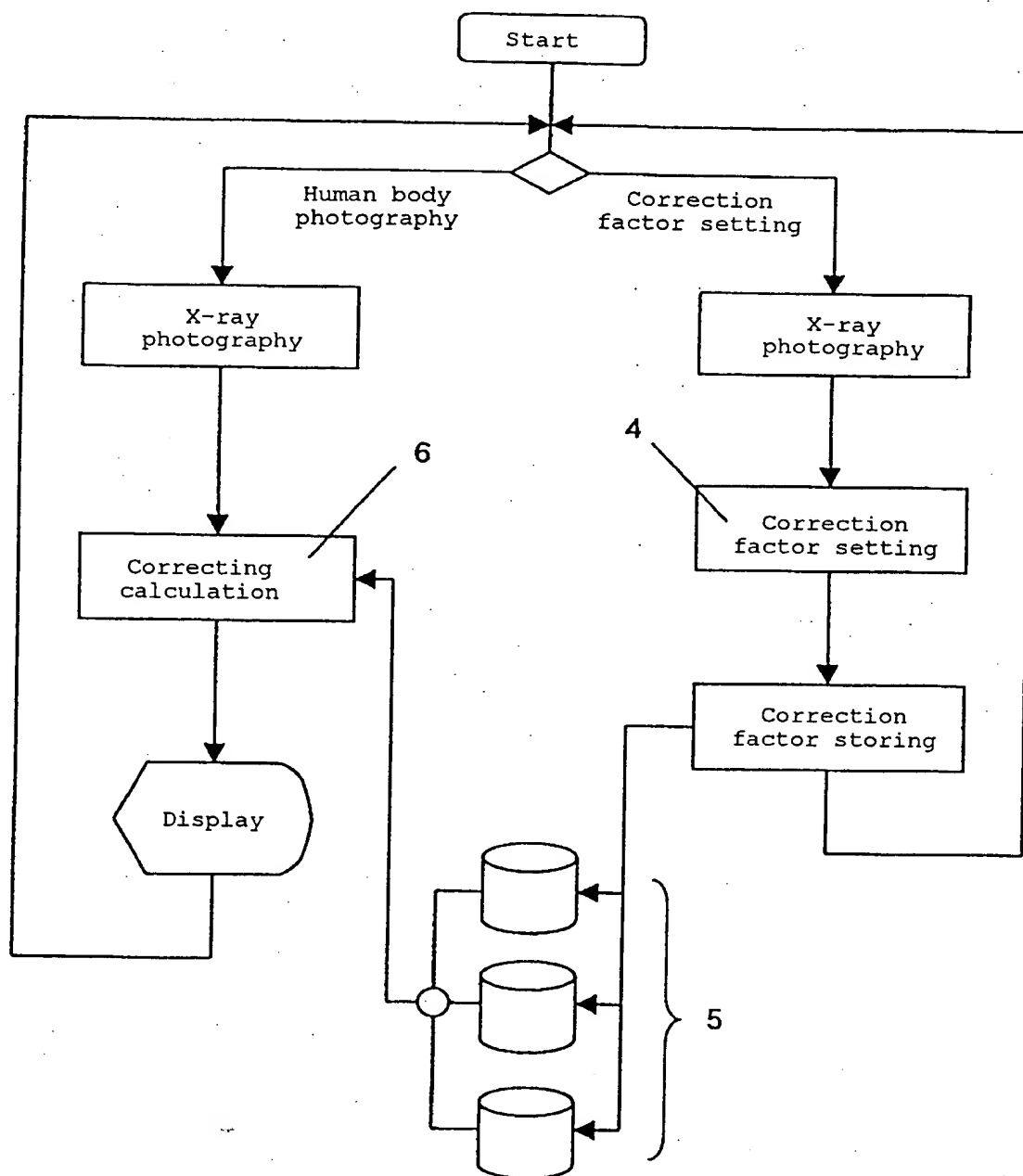


[Fig. 2]



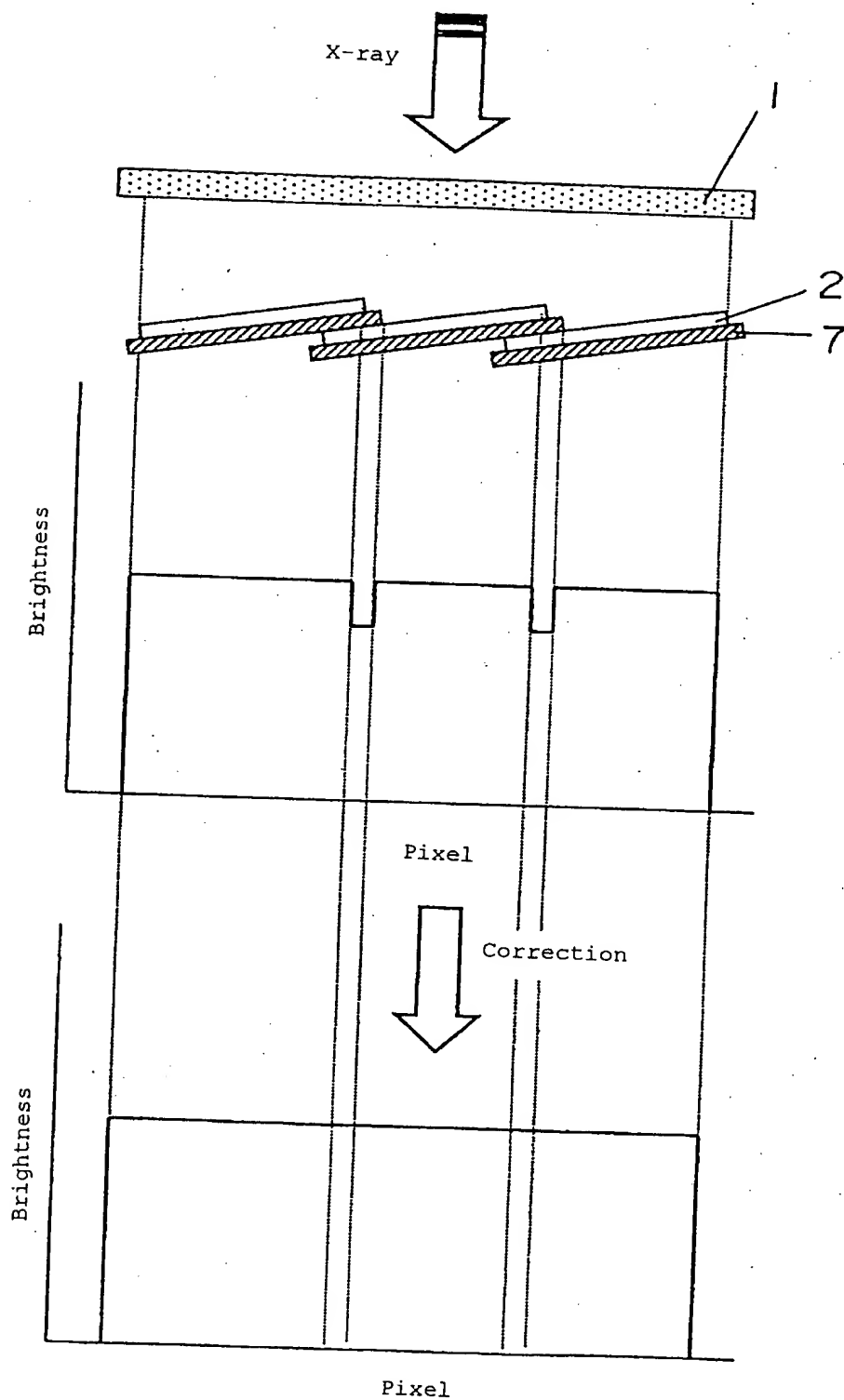
- 4 Correction factor setting means
- 5 Storage means
- 6 Correction means

[Fig. 3]



- 4 Correction factor setting means
- 5 Storage means
- 6 Correction means

[Fig. 4]



[Fig. 5]

